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Sixteenth day of February 2005

JANENE PEISKER
TEAM LEADER EXAMINATION
SUPPORT AND SALES

# DEVICES TO FACILITATE ALIGNMENT AND FOCUSSING OF A FUNDUS CAMERA

This invention relates to improvements in devices for alignment and focussing of a fundus camera.

A fundus camera is used to capture an image of the fundus (posterior portion of the eye, including the retina and blood vessels). This fundus image can be examined by a third party or compared to fundus images taken at an earlier date, to facilitate diagnosis of retinal disease. The fundus camera comprises an objective lens to form an image of the fundus of the eye, other lenses to form an image on the recording plane of a camera, and an illumination system to project light into the eye so that the fundus image is sufficiently bright that an image may be captured on the camera. To enable a useful image to be formed without unacceptable reflections from the anterior parts of the eye (including the cornea, iris and vitreous lens) the fundus camera must be aligned very accurately. For capture of fundus images without mydriasis to dilate the pupil, the required accuracy of fundus camera alignment is difficult to achieve without features to guide the operator in the focus and alignment of the fundus camera. Various devices have been proposed to project marks onto the eye to facilitate alignment and focus. These devices have various disadvantages in complexity or performance.

To facilitate accurate focussing of the fundus camera, one or more marks may be projected onto the eye fundus and the image of these marks may then be observed though the fundus camera. Further, split prisms may be provided within the line projection system such that the image of the projected marks on the eye fundus appears split if the camera is not correctly focussed, as discussed in US patent 3,925,793. The optical components for such a system for projecting a mark to aid focussing may be separate from the illumination system and combined with an afocal lens system, such that the focus of the viewing system and the focal plane of the projected line system may be maintained coincident as the focus of the viewing system is adjusted as discussed in US patent 4,187,014. The afocal lens system required for this invention has a disadvantage that the magnification of the image appearing at the camera imaging plane changes through a large range as the focus is adjusted and this varies the area of the fundus and the apparent brightness of the image through a large range. Alternatively, the optical components for such a system for projecting a line to aid focussing may be separate from all or part of the focussing and illumination systems and these optical components may be moved by cams or linkages or similar means such that the focus of the viewing system and the focal plane of the projected line system may be maintained coincident as the focus of the viewing system is adjusted as discussed in US patent (tba????). This

alternative allows the use of a lens of reduced or negative power as the focussing lens such that the change in image magnification is reduced, but the required cams or linkages increase the mechanical complexity of the system.

It is an object of this invention to provide a means of adjusting the focus of a projected mark focus aid system that is simple in construction while not requiring an afocal system to be used for the image focus adjustment system.

According to the present invention, a first auxiliary lens separate to the image focusing system is connected to the image focus adjustment lens with a simple rigid arm or similar connection. Second and third fixed lenses may be placed either side of the auxiliary lens such that these lenses do not move with movement of the auxiliary lens. A focus aid mark is formed by a slit with a pair of deflecting prisms that deflect the light from the slit along separated optical paths such that two images of the slit are formed that are only aligned to form a single image of the slit at a focal plane of the focus aid mark projection system. This focus aid mark is projected though the focus aid mark projecting lens system and through a system of mirrors and the fundus camera objective lens to form an image of this focus aid mark on the eye fundus. If the power of the auxiliary and second and third fixed lenses and the auxiliary lens are chosen correctly, the focus of the imaging system and the focal plane of the projected line system may be maintained coincident for any position of the image focus adjustment lens as the focus of the viewing system is adjusted by moving the image focus adjustment lens. The effect of the second and third fixed lenses is that the image focus adjustment system does not have to be an afocal system as specified in US patent 4,187,014. Thus a design with a negative focus adjustment lens may be used with consequent reduced change in image magnification and image brightness when compared with the afocal imaging focus adjustment system. Also the geometry of the lens system and resultant focal plane can be controlled by correct choice of the lenses to allow sufficient length in the optical path for incorporation of the mirrors required to combine the imaging and projected focus mark aid optical paths in a practical instrument.

To facilitate accurate alignment of the fundus camera, one or more alignment aid marks may be projected onto the iris of the eye. Two alignment marks may be projected so that when the fundus camera is correctly positioned, the two alignment marks are coincident and in focus on the iris of the eye (US Patents 4,257,688; 4,252,420; 4,253,743). In a previous invention (application PCT/AU02/01681) such alignment marks have been implemented by mark projection optics that are either external or internal to the fundus camera optics. It is preferable that the alignment marks are projected from a source internal to the fundus camera and then through the objective lens to the subject eye to minimise the bulk of the instrument in the vicinity of the subjects eye and minimise the number of additional optical components required to form the projected alignment marks. The projected alignment and focus marks may be formed in infrared light and the observation system includes a camera sensitive to infrared

light, so that projection of the marks into the subject's eye does not cause the subject's pupil to contract.

It is an object of this invention to provide a means of implementing a projected alignment mark system that is simple in construction and compact by combining the alignment mark system with the illumination system that already exists in the fundus camera and generating the two alignment marks discussed in PCT application PCT/AU02/01681 from one light source.

According to the present invention, the alignment targets are formed from an image of a slit, with a pair of deflecting prisms arranged adjacent to the slit as for the focus aid projection system discussed above to divide the light from the light source into two separate paths. Alternatively, the light from the light source may be divided into two separate paths by reflection from a pair of mirror surfaces adjacent to the slit, where the mirrors are rotated relative to each other about an axis passing through each mirror surface and orthogonal to the axis of the optical path. Light from the slit is combined with the light from the fundus illumination system by a mirror or prism such that the slit is conjugate with a first stop in the illumination system. When the fundus camera is correctly aligned an image of the first stop is formed in the plane of the eye pupil. An image of the alignment target slit is also formed on the iris of the eye. If the fundus camera is not correctly aligned, the image of the alignment target slit will be split into two lines because of the split prism adjacent to the alignment target slit.

To assist with understanding the invention, reference will now be made to the accompanying drawings which show at least one example of the invention.

In the drawings :

FIG 1 shows one example of a fundus camera with projected focus aid marks as proposed in US patent 4,187,014.

FIG 2 shows an improvement of the design depicted in fig 1 where two additional lenses 14 and 15 are interposed either side of lens 10, as proposed in this patent application

Fig 3 shows a variant of the improved design depicted in fig 2, whereby the focussing lenses 6 and 10 are negative (diverging) lenses.

Fig 4 shows how the focussing lenses 6 & 10 move together to focus the instrument on a new first image plane 3'

Fig 5 is a graph of how the focussing lens position x1 varies with a movement of the first image plane x2

Fig 6 depicts the change in magnification of the image at the second image plane 8

FIG 7 is a graph showing the effect of varying the ratio of powers of the fixed lenses 14 & 15 on the movement of focal plane of the projected focus aid mark with movement of the focussing lens 10.

Fig 8, 9 & 10 depict the alignment target projection system as proposed in patent application PCT/AUO2/01681

Fig 11 shows an improved method for projecting an alignment target

Fig 12 shows the appearance of the alignment target projected onto the iris of the subject eye.

Referring now to the drawings, Fig 1 shows one example of a fundus camera with projected focus aid marks as described in US patent 4,187,014. In this invention, the focus aid mark projection system is implemented via components 5,9,10,11,12,13, where components 10,11,12,13 move in parallel with the imaging focussing lens thereby maintaining the focal plane of the focus aid marks conjugate with the focal plane of the imaging focal plane. This system has the claimed advantages of simplifying the mechanical design of the focus aid mark projection system, and separating the focus aid mark projection system from the illumination system of the fundus camera.

Fig 2 shows and improvement which is the subject of this patent application, whereby two fixed lenses 14 & 15 are interposed either side of the moving focus aid mark auxiliary lens 10. This design allows freedom in the design of the image focussing system as this system does not have to be an afocal system as specified in the design depicted in fig 1. Also, only the lenses 10 and 6 are connected to move in parallel in fig 2, so that the remainder of the focus aid mark projection system (items 11, 12 and 13) are fixed thereby simplifying the design of the fundus camera further. As depicted in fig 3 & 4, the improved design of fig 2 allows the use of a negative focussing lens 6, as is commonly used in fundus camera. Said negative lens has the desirable effect of reducing the change in magnification of the fundus image at the imaging plane 8, thereby reducing the change in field of view and apparent brightness of the image. By varying the power of the two fixed lenses 14 & 15, the relationship between the movement of the focal plane of the focus aid mark and the movement of the focussing lens 10 can be varied. By correct choice of the fixed lenses 14 & 15, and the focussing lens 10, the focal plane of the focus aid mark and the focal plane of the imaging system can be maintained coplanar as the focussing lenses 6 & 10 are moved to adjust the focus of the fundus camera for different subject eye refractive error.

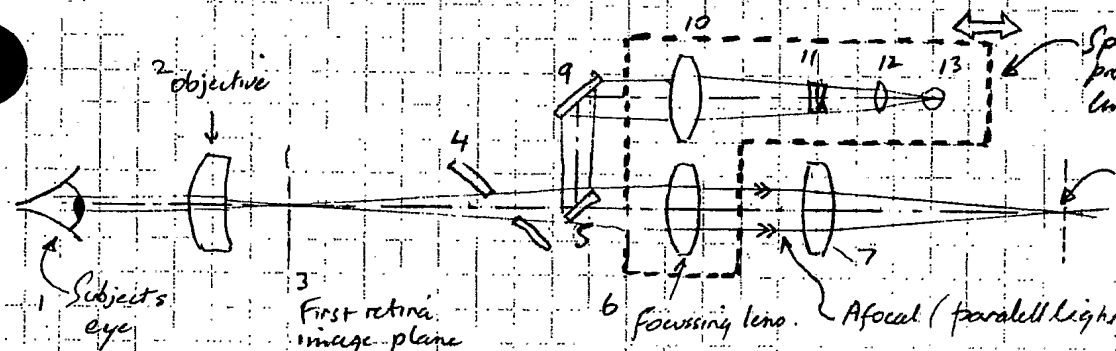



Fig 1 DESIGN AS PER USPAT 4187014 (FEB 1980)

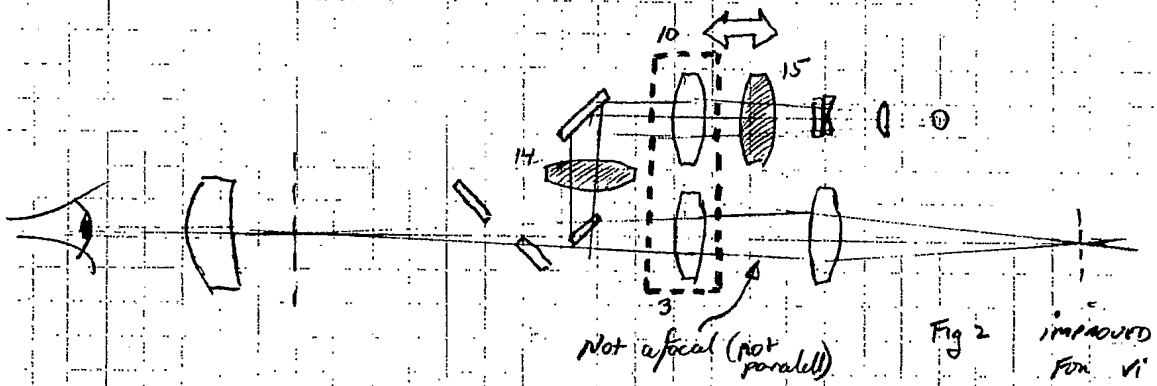



Fig 2 IMPROVED DESIGN FOR VI PATENS APPLICATION

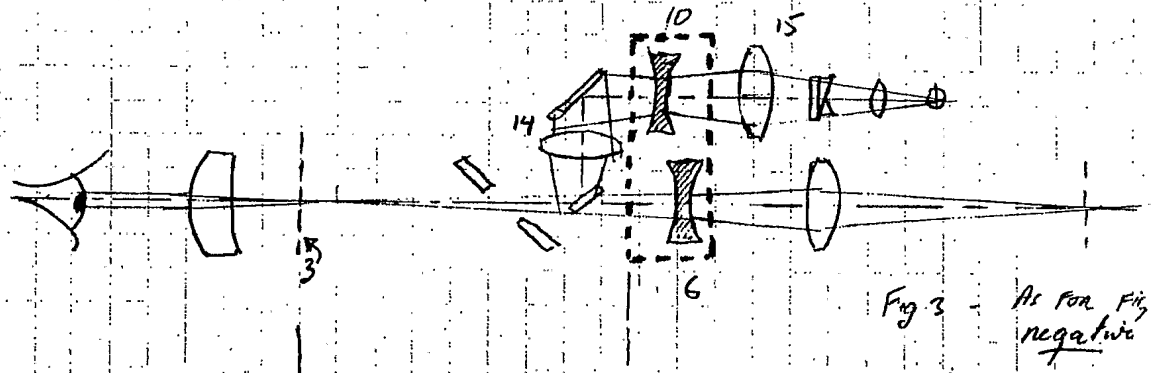



Fig 3 - As for Fig 2, But with negative (diverging) lens 10

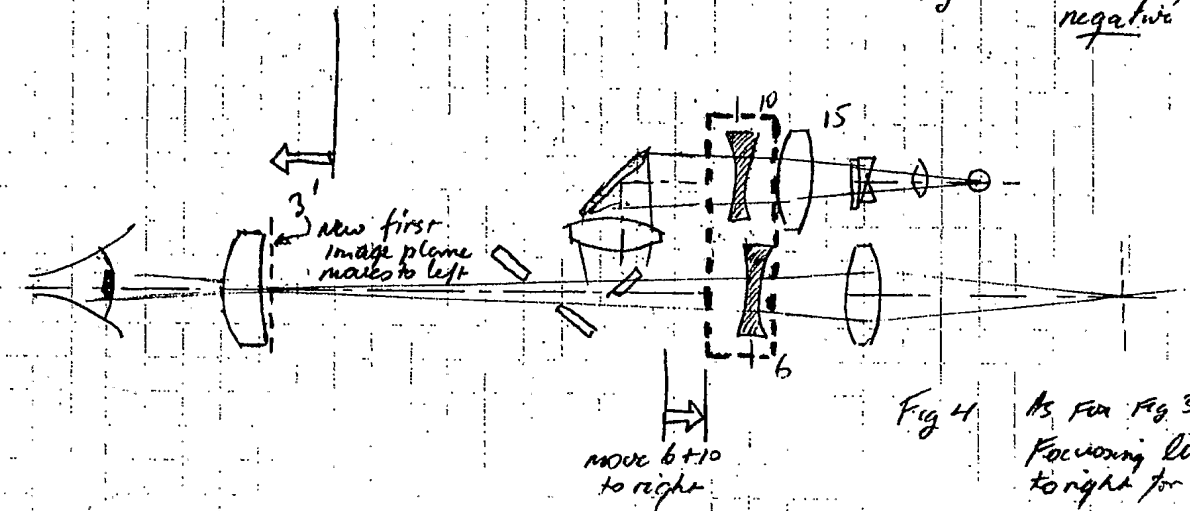



Fig 4 As for Fig 3, But with Focussing lens 6 + 10 moved to right for myopic subject.

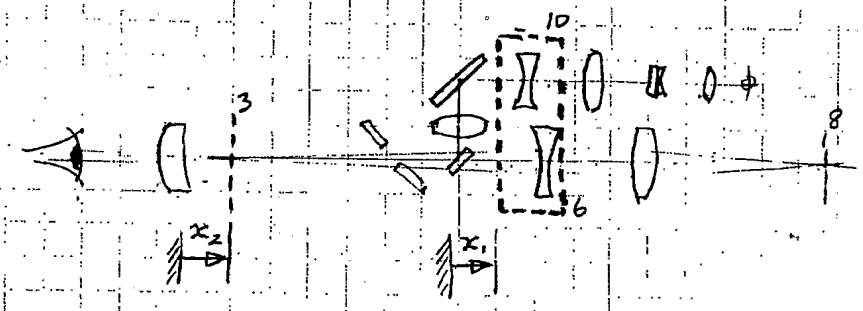



Fig 5 effect of magnifying power of focussing lenses 6+10

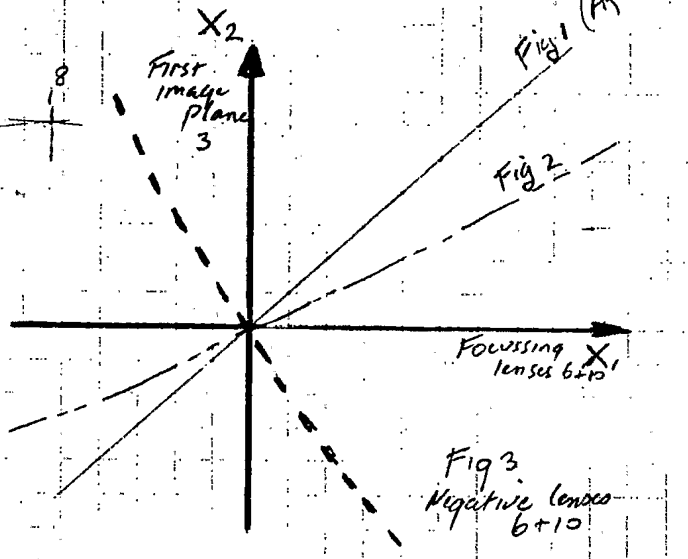



Fig 3 Negative lenses 6+10

Fig 6 Change in magnification of retinal image 8 with focus adjustment. $x_1$

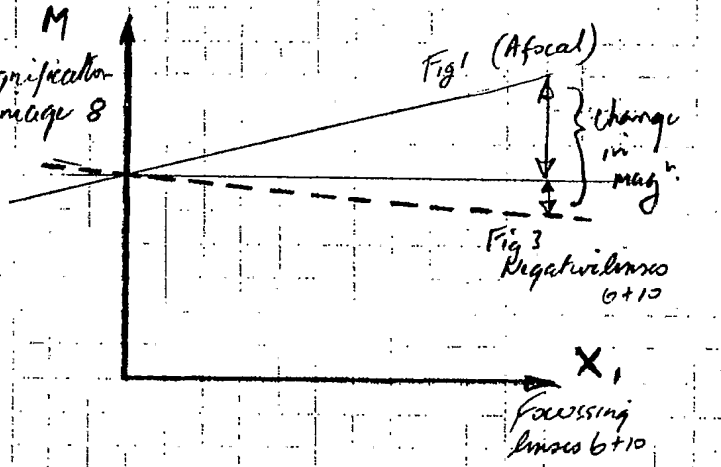
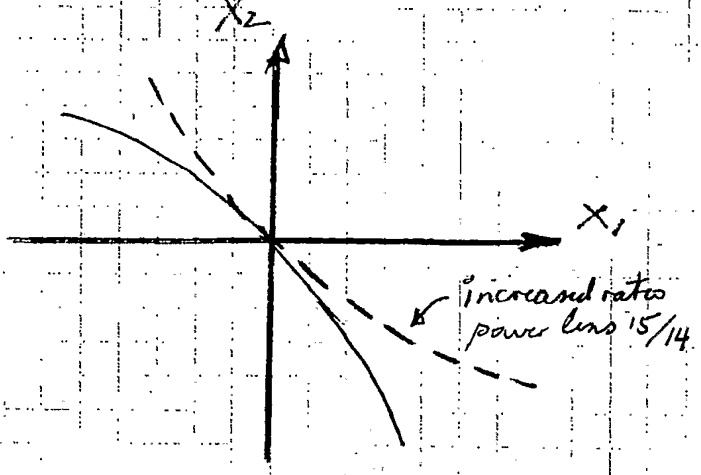



Fig 7 effect of changing power of lenses 14+15



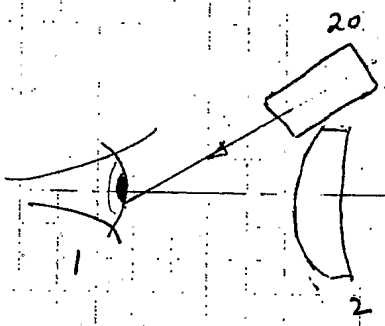



Fig 8 External alignment target projector

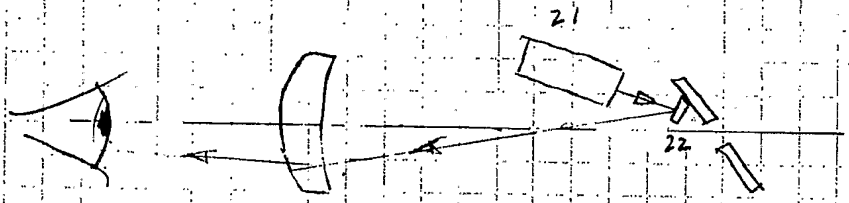



Fig 9 Internal alignment target projector.

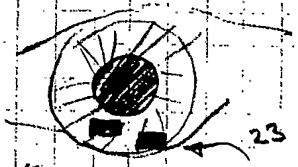



Fig 10a Incorrect axial position

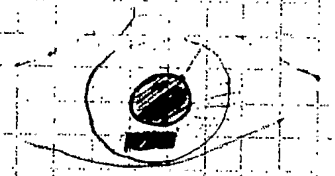


Fig 10b correct axial position

Fig 10 resultant alignment marks.

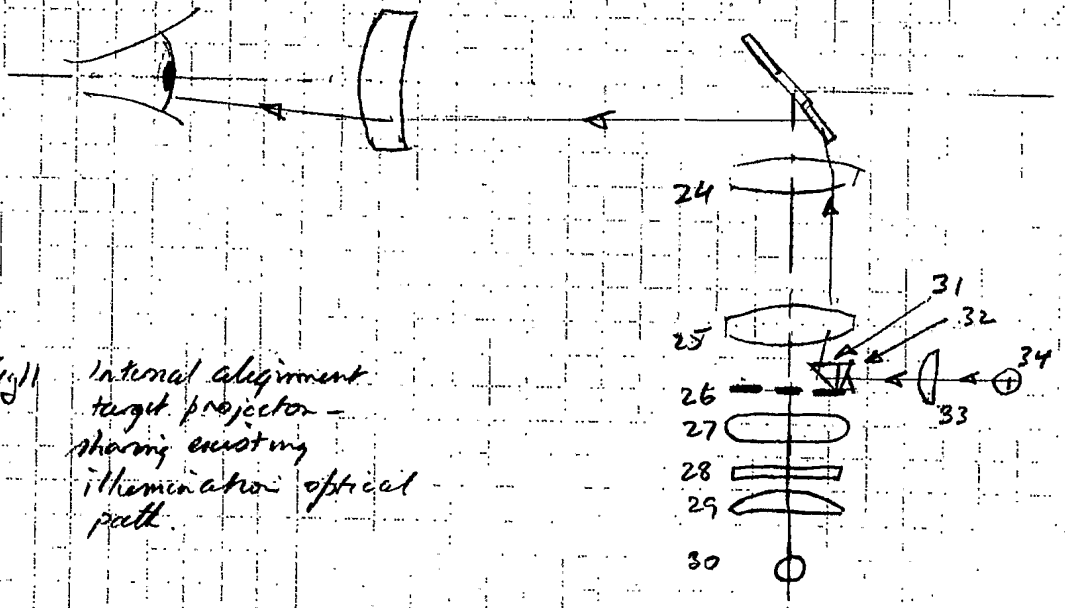



Fig 11 Internal alignment target projector - sharing existing illumination optical path.

Fig 12 Resultant alignment marks

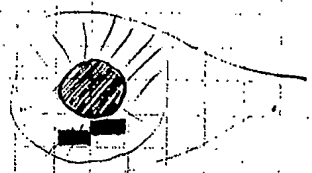


Fig 12a incorrect axial position

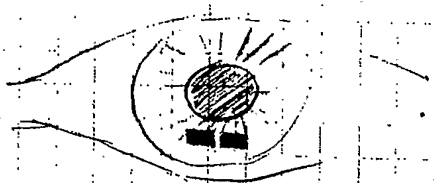


Fig 12b correct axial position